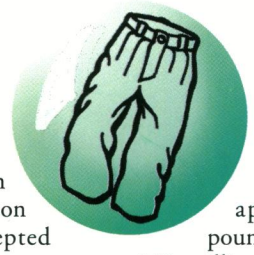
A CLEANER BILL OF HEALTH



Liquid carbon dioxide (CO_2) is getting serious consideration as the dry cleaning fluid of the future. With encouragement from the EPA's Design for the Environment program, liquid CO_2 could replace perchloroethylene—known as "perc"—today's dry-cleaning solvent of choice. Perc, a chlorinated hydrocarbon, has been linked to cancer and other health problems.

Based on animal studies and other data, the International Agency for Research on Cancer (IARC) calls perc a probable human carcinogen. The EPA puts the solvent in the possible-to-probable category of carcinogens.

James Huff, a toxicologist with the NIEHS, says perc-cleaned clothes pose virtually no cancer risk to the wearers; the amount of perc on such clothing is probably negligible. The NIEHS has reported, however, that rats exposed to perc vapors have an increased incidence of leukemia and kidney tumors, and mice similarly exposed have increased numbers of liver tumors. Moreover, Huff says, epidemiological studies have linked perc-contaminated drinking water to increases in leukemia in an exposed population cohort and to increased urinary, bladder, and esophageal cancers in perc-exposed dry-cleaning workers. Other perc-related cancers include cervical cancer and non-Hodgkin's lymphoma. Because of these data, Huff believes occupational exposures to perc do present a hazard.

Robin Hill, a risk manager at Health Canada, says, that Canadian health authorities disagree with IARC, and don't think the evidence is strong enough to label perc a human carcinogen. Even so, cutting back on perc seems to be a widely accepted goal, even in Canada. The Ontario government has already proposed reducing workplace exposure from 50 parts per million (ppm) during an 8-hour workday to 10 ppm.

While current regulations of the Occupational Safety and Health Administration (OSHA) limit worker exposure to 100 ppm, the agency is examining evidence to see if the standard should be changed. "There is a long-standing relationship between the agency [OSHA], the dry-cleaning industry, and public interest groups aimed at reducing exposure," says Joseph Cotruvo, who oversees chemical screening and risk assessment at the EPA's Office of Pollution Prevention and Toxics.

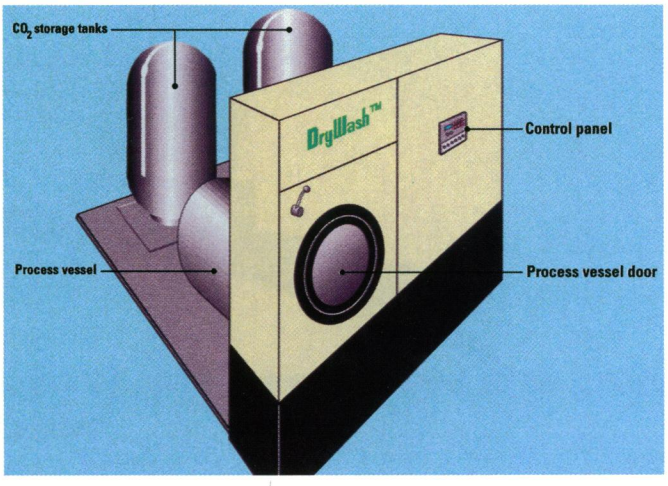
The U.S. dry-cleaning industry, which employs more than 250,000 people, has taken steps to cut back on perc usage. "Perchloroethylene use in 1988 was approximately 250 million pounds in the U.S.; in 1994 it was 150 million pounds," says Mary Scalco, director of government relations for the International Fabricare Institute (IFI), the dry-cleaning trade association. She says improved technology is the primary reason for the decrease. And attempts to develop alternate methods in dry-cleaning are being explored with the support of several agencies, including the EPA, and industry.

Liquid CO_2

One technology being investigated uses liquid carbon dioxide (CO_2) as a dry-cleaning solvent. Hughes Environmental Systems of El Segundo, California, has developed a prototype dry-cleaning machine and process called DryWash. The system, which uses liquid CO_2, was exhibited in Milan at an international dry-cleaning exposition in March. While the EPA's Design for the Environment program hasnot funded research on liquid CO_2, it has held conferences and encouraged the exchange of information about its potential.

Sid Chao, president of Hughes Environmental Systems, says liquid CO_2 doesn't have the environmental and health drawbacks of perc. OSHA limits exposure of CO_2 to 5,000 ppm for an 8-hour day.

Liquid CO_2 for dry-cleaning would come from industrial processes, including fermentation and ammonia manufacture, that produce CO_2 as a waste



What's in a name? A new technology called DryWash uses liquid carbon dioxide to clean clothes.

product. The CO_2 would be processed by a gas manufacturer and delivered to dry-cleaners in pressurized canisters, the same way it is delivered to restaurants.

In dry-cleaning establishments, the liquid CO_2 would be recycled after use and purified for reuse. The gas, though, would gradually escape into the atmosphere by adsorbing into clothes and leaking from dry-cleaning drums when they are opened to remove clothes. Hughes officials emphasize that its DryWash system does not create any new CO_2. It captures and recycles what is already produced. Although the exact amount of CO_2 that would be recaptured per cycle is considered proprietary information by Hughes, Jerome Barton, a scientist at the Los Alamos National Laboratory (LANL) who has worked on the liquid CO_2 cleaning process, says that the amount would be "far in excess of 90%."

Liquid CO_2 would speed dry-cleaning, says Chao. "Once the dry-cleaning is finished, the clothes can be taken out and need no drying. Because of that there is a shorter cycle time. We're looking at less than 30 minutes. The perc-based cycle time is 40 to 50 minutes," he says.

Moreover, liquid CO_2 can clean items that perc-based systems can't, says Jack Belluscio, CEO of Caled Chemical Company, which makes dry-cleaning additives and is a partner with Hughes in developing the liquid CO_2 process. Liquid CO_2 can clean leather, suede, and fur, which perc-based systems typically can't, says Belluscio. Also, unlike perc, liquid CO_2 won't dissolve sequins.

Since 1994, Hughes has been working to develop the liquid CO_2 technology for dry-cleaning under a Cooperative Research and Development Agreement with the LANL. Researchers at the LANL, funded by the Department of Energy and the EPA's Environmental Technology Initiative, have been doing the basic and applied research to determine how well CO_2 performs as a solvent. Because liquid CO_2 is nonpolar, it dissolves organic compounds, including many materials that commonly soil clothes, and releases them from the surface of garments.

"We have found that CO_2 is very effective in removing oils, greases, sweat, etc.," says Los Alamos chemist Craig Taylor of the tests performed on swatches of clothes in a 60-liter drum. "By using agitation, we find that we get good removal of soils and particulates." During the process, clothes are soaked in a liquid CO_2-filled drum. Then liquid CO_2 is sprayed through nozzles onto clothes to agitate them and remove dirt.

Hughes doesn't plan to actually produce its prototype machine for the market. Chao says the firm is planning to license the technology to a manufacturer and estimates that the machines will be ready for sale by 1997.

Unfinished Work, Unanswered Questions

But research on the liquid CO_2 cleaning process is hardly complete. One problem Taylor is working on is the removal of proteinaceous stains, such as grass stains, lipstick, and chocolate. Dry cleaners currently get rid of these stains by using surfactants to pretreat the stains before the clothes go into the dry-cleaning drums. The problem, Taylor says, is that surfactants don't work well in liquid CO_2. He and his colleagues are working to modify the surfactants so they will.

Another concern, voiced by Dale Spall, a recently retired chemist who worked on liquid CO_2 at Los Alamos, is that clothes colored with vegetable dyes might shrink when cleaned with liquid CO_2.

While Spall praises the use of liquid CO_2 as innovative and says it shows a great deal of potential, other dry-cleaning industry specialists are cautious. Manfred Wentz, vice president of research and development at R.R. Street and Company, which makes and distributes dry-cleaning chemicals and additives, says additives have to be developed to prevent stains removed by liquid CO_2 from being redeposited on clothes during the cleaning process. While he says research of such additives is being pursued, "nothing has been adequately documented yet. I think the problem can be overcome but it requires a systematic analysis of the liquid CO_2 process." Chao disputes this statement: "Our technology is such that it minimizes the redeposition of dirt. Our tests indicate that it is better than the perc process."

Besides performance, other questions remain about how a liquid CO_2-based system would fit into the operations of the approximately 30,000 dry-cleaning establishments in the United States.

Cost is one crucial concern for dry-cleaners. "Commercial dry-cleaning is not a high-profit business, and many dry-cleaners are barely able to stay in business," states a 1995 EPA profile of the trade. Acording to the EPA report, the cost to start up a dry cleaning business in 1993 was $113,000.

Scalco says that she's seen no information on the cost of liquid CO_2 machines from Hughes, but "for liquid CO_2 [to be a viable option] you have to have equipment that's affordable. That's probably the biggest thing right now."

"Can we provide a system where the unit costs per pound for producing a clean garment are comparable [with existing technology]?" wonders Wentz. He notes that liquid CO_2 may have some economic factors in its favor. The shorter cleaning cycle means more garments can be cleaned in less time. Furthermore, labor costs for finishing or pressing the garments may be reduced, since the garments are cleaned at lower temperatures, which reduces wrinkling. Such factors will help determine if the liquid CO_2 process will fit within the present dry-cleaning infrastructure, says Wentz.

If the DryWash machines prove too costly for individual "mom and pop" dry-cleaners (which make up most of the dry-cleaning operations in the United States, according to the EPA), the machines may find homes in central facilities, with customers dropping their clothes off at storefronts or so-called "dry stores" to be taken to the central facilities for cleaning. This is already a trend in dry-cleaning, says Scalco. But this system may negate some of liquid CO_2's potential environmental advantage by causing increased fuel consumption and pollution from transporting the clothes, Wentz cautions. A life-cycle study of factors such as these would have to be done to assess the advantage of liquid CO_2 from an environmental perspective.

Wet-cleaning

Wet-cleaning is another method being examined to replace perc. Highly touted by the environmental activist group Green-

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High-tech soap and water. (left to right) Plant manager Ann Hargove, owner Noam Frankel, and project coordinator Jo Patton are testing a wet-cleaning method at The Greener Cleaner.

peace, this European-developed method uses water and specially designed soaps instead of solvents to clean clothes.

The machines that do the cleaning are sophisticated washers and dryers in which humidity, agitation, and heat are computer controlled. "By controlling all those factors in a better way, it's possible to clean clothes with water that used to be dry-cleaned," says Jack Weinberg, a campaigner against toxic chemicals for Greenpeace.

Wet-cleaning, or wet wash as it is sometimes known, is used in Germany and Austria and has also been tried on a demonstration basis in the United States and Canada.

With funding from the EPA, Greenpeace, and the Center for Neighborhood Technology (CNT) in Chicago have been examining how well wet-cleaning cleans clothes in a study with the Greener Cleaner, a private dry-cleaning business that has been operating since May 1995. The study is part of an agreement between Greenpeace, the CNT, and the IFI to assess perc alternatives.

Jo Patton, CNT project director for the wet-cleaning demonstration, says the wet-cleaner has successfully cleaned virtually all garments brought to it, rejecting only about one-tenth of a percent because tests at the store showed that dyes would run. She says wet-cleaning has been able to clean clothing made of wool, silk, rayon, cotton, and blends of fabrics. Weinberg claims that even leather can be wet-cleaned satisfactorily.

Suggested Reading

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In Canada, a wet-cleaning demonstration project begun in 1994 and funded in part by the government reported that 30–80% of garments currently dry-cleaned can be satisfactorily wet-cleaned, a figure far greater than the 3–15% of clothes (excluding shirts) now cleaned in water at dry-cleaners. A report on the project, which involved six cleaning facilities, concluded, however, that wet-cleaning "does not appear to be a complete replacement for perc." The report also concluded that higher labor costs may accompany wet-cleaning because wet-cleaned clothes can require increased hand finishing. Wet-cleaning does, however, offer decreases in electric and chemical use and removes the health problems linked to perc exposure, the report stated.

Wet-clean machines cost between $15,000 and $20,000, and dryers between $4,000 and $18,000. The Canadian report says the "initial investment in water-based technology is considerably lower than for new perc equipment." The report, however, calls for more information on the financial feasibility of using wet-cleaning technology.

Although perc is currently the dry-cleaning solvent of choice, according to Scalco, it's clear that governments, environmentalists, and the dry-cleaning industry are choosing to look for alternatives and ways to reduce its use.

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